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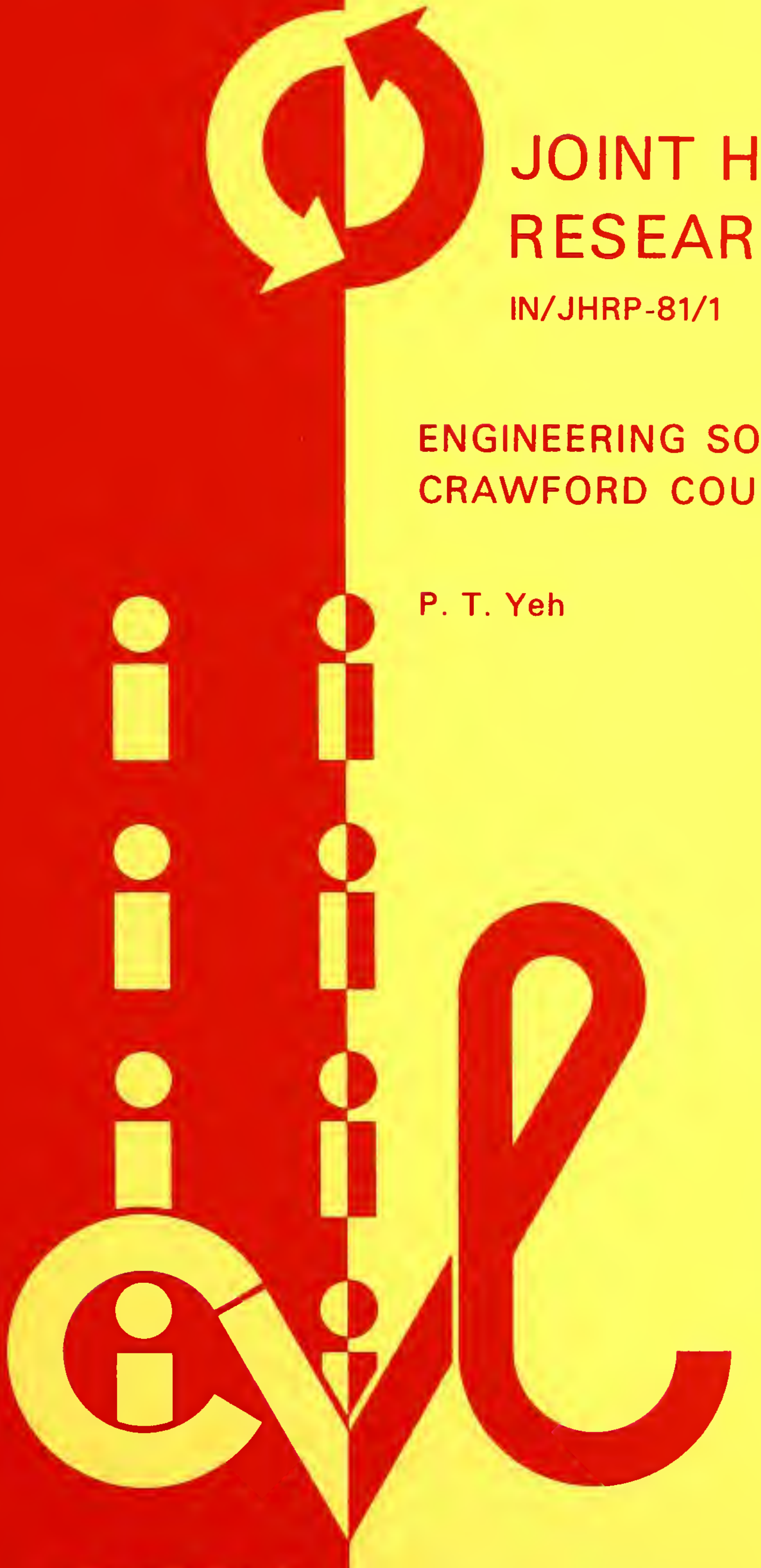

JOINT HIGHWAY RESEARCH PROJECT

IN/JHRP-81/1

ENGINEERING SOILS MAP OF CRAWFORD COUNTY, INDIANA

P. T. Yeh

PURDUE UNIVERSITY
INDIANA STATE HIGHWAY COMMISSION

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ENGINEERING SOILS MAP OF CRAWFORD COUNTY, INDIANA

TO: H. L. Michael, Director
Joint Highway Research Project

FROM: P. T. Yeh, Research Engineer
Joint Highway Research Project

February 3, 1981

Project: C-36-51B
File: 1-5-2-64

The attached report, entitled "Engineering Soils Map of Crawford County, Indiana", completes a portion of the project concerned with development of a county engineering soils map of the state of Indiana. This is the sixty-fourth report of the series. The report was prepared by Dr. P. T. Yeh, Research Engineer, Joint Highway Research Project.

The soils map of Crawford County was performed primarily by use of the soil survey map sheet published by the Soil Conservation Service, United States Department of Agriculture in the Soil Survey of Crawford County. Air-photo interpretation techniques were used to supplement the pedological data. Some test data along I-64 and SR 37 were included in the report. Generalized soil profiles of the major soils from each land form are presented on the engineering soils map. An ozalid print of the Engineering Soils Map of Crawford County is included in the report.

Respectively submitted,

P. T. Yeh
Research Engineer

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Final Report

ENGINEERING SOILS MAP OF CRAWFORD COUNTY, INDIANA

by

P. T. Yeh
Research Engineer

Joint Highway Research Project
Project No. C - 36 - 51B
File No. 1 - 5 - 2 - 64

Prepared as part of an Investigation

Conducted By

Joint Highway Research Project
Engineering Experiment Station
Purdue University

in Cooperation with Indiana State Highway Commission

Purdue University
West Lafayette, Indiana
February 3, 1981

ACKNOWLEDGMENTS

The author wishes to acknowledge the assistance given by all those persons who have helped in preparation of the report. Special acknowledgments are due to the members of the Advisory Board, Joint Highway Research Project for their active interest in furthering the study and Professor R. D. Miles, in charge of the Airphoto Interpretation, Photogrammetry and Site Selection Laboratory for review and suggestions.

All 1940 airphotos used in connection with the preparation of this report automatically carry the following credit line: photographed for Commodity Stabilization Service, Performance and Aerial Photography Division, United States Department of Agriculture.

ENGINEERING SOILS MAP OF CRAWFORD COUNTY, INDIANA

Introduction

The engineering soils map of Crawford County, Indiana which accompanies this report was done primarily by grouping the agricultural soil series into appropriate land forms and parent materials from the detailed pedological soils maps published in the 1975 soil survey of Crawford County prepared by the United States Department of Agriculture Soil Conservation Service and Forest Service in cooperation with Purdue University's Agriculture Experiment Station (1)*.

Routine airphoto interpretation techniques (2) were used on the available 1940 airphotos (Scale: 1/20,000) to delineate land forms, parent materials, and soil textures. The boundaries of soils determined from the airphotos were then compared with the agricultural soils map and a correlation of the soil series and the engineering soils maps were established. Delineation of the soil boundaries of the engineering soils map were derived mainly from the grouping of the series from the agricultural soils map sheets.

The soil boundaries were reduced to the scale of the engineering soils map (1 inch = 1 mile) by projection. Standard symbols developed by the staff of the Airphoto Interpretation Laboratory of Purdue University's School of Civil Engineering were employed to delineate land forms, parent materials and soil textures. The text of this report largely represents an effort to overcome the limitations imposed by adherance to a standard symbolism and map presentation.

No soil samples were collected and tested by the staff at the Joint Highway Research Project, but general soil profiles were developed and are shown on the soil map. The soil profiles were compiled from the agricultural literature and from the boring data of the roadway soil survey along I-64 and SR 37. These data were supplied by the Indiana State Highway Commission. Liberal reference was made to the "Formation, Distribution and Engineering Characteristics of Soils" (3).

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* Numbers in parentheses indicate reference in the Bibliography.

Description of the Areas

General

Crawford County is located in the extreme south central part of Indiana. English, the county seat is located near the geometric center of the county. The county is irregular in shape along its eastern and southern boundaries which follow the courses of the Blue River and the Ohio River. The county is bounded on the east by Harrison County, on the northeast by Washington County, on the north by Orange County, on the west by Dubois County, on the southwest by Perry County, and on the southeast by the Ohio River (Figure 1).

Crawford County has an area of 312 square miles or 199,680 acres (808 sq km) (4). About 50% of the land was covered with trees in 1964 (1). According to the 1974 Census of Agriculture about 22.6% of Crawford County or 45,113 acres (182.5 sq km) was farm land and about 26.7% of the county or 52,861 acres (214 sq km) was wooded farm land (4). The farm lands were generally confined to ridge tops and valley bottoms where the topography varies from gently sloping to flats as shown in Figure 2.

Crawford County had a population of 8,033 in 1970 with 664 residing in English as reported in the census (5).

Drainage Features

Crawford County lies in three drainage basins. The eastern quarter of the county lies within the Blue River drainage basin. The northwestern quarter of the county lies within the Patoka River drainage basin. The remainder of the county lies within the Minor Ohio River drainage basin.

Surface drainage is well developed in Crawford County. The density of the drainage pattern varies according to the bedrock and topography. The western half of the county is more dense than the eastern half of the county (Figure 3). Sinkholes and subterranean drainage patterns are more evident in the eastern part of the county. Large springs exist in the limestone region along the Blue and Ohio River. Streamless or semi-streamless valleys are not uncommon in this region. Wyandotte and Marengo caves are also located in the limestone region of Crawford County. Both southerly flowing Blue River and Little Blue River have tortuous courses. Rock control is clearly evident in the drainage map (Figure 3). Control exists also in the Turkey Fork and Bogard Creek tributaries of the Little Blue River and in the lower course of the Dry Run tributary of the Blue River.

Little Patoka River and the Fleming Creek tributaries of the Patoka River flow in a northerly direction. The drainage pattern is denser and more uniform than the pattern in the eastern portion of the county.

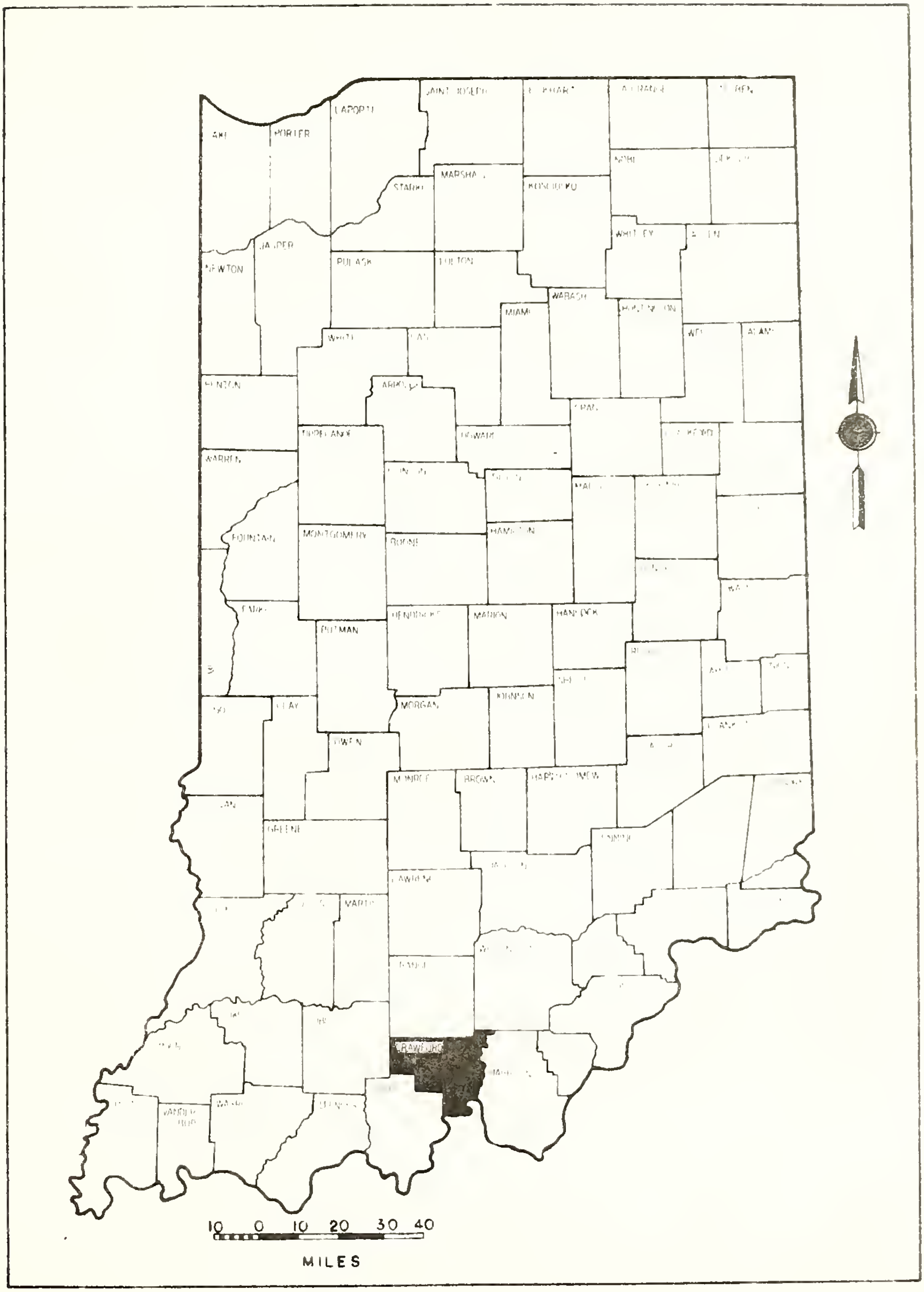


FIG I LOCATION MAP OF CRAWFORD COUNTY

Fig. 2: Airphoto Mosaic of Crawford County

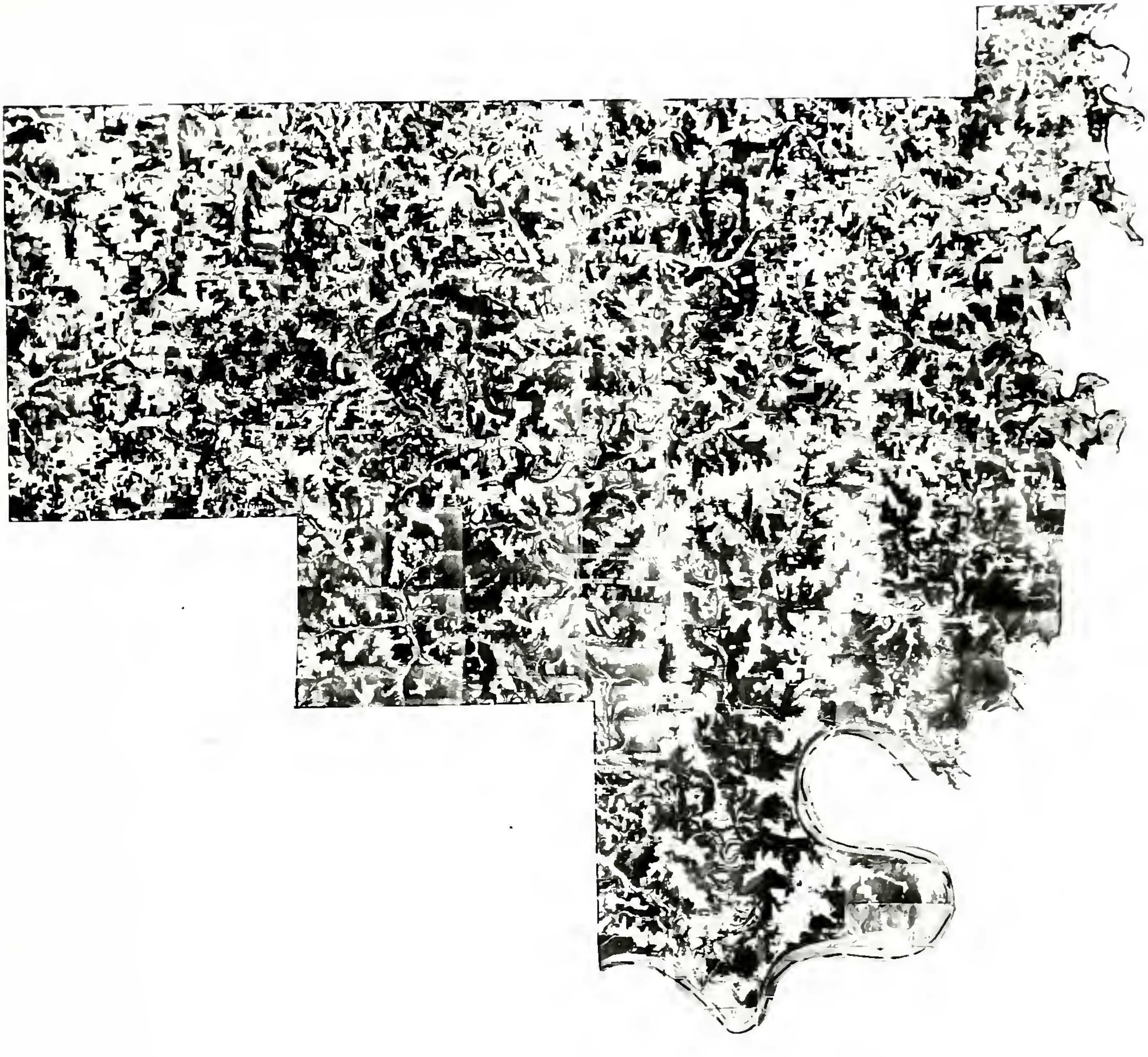


FIG 2 AIRPHOTO MOSAIC OF CRAWFORD COUNTY, INDIANA

FROM 1940 INDEX MAP

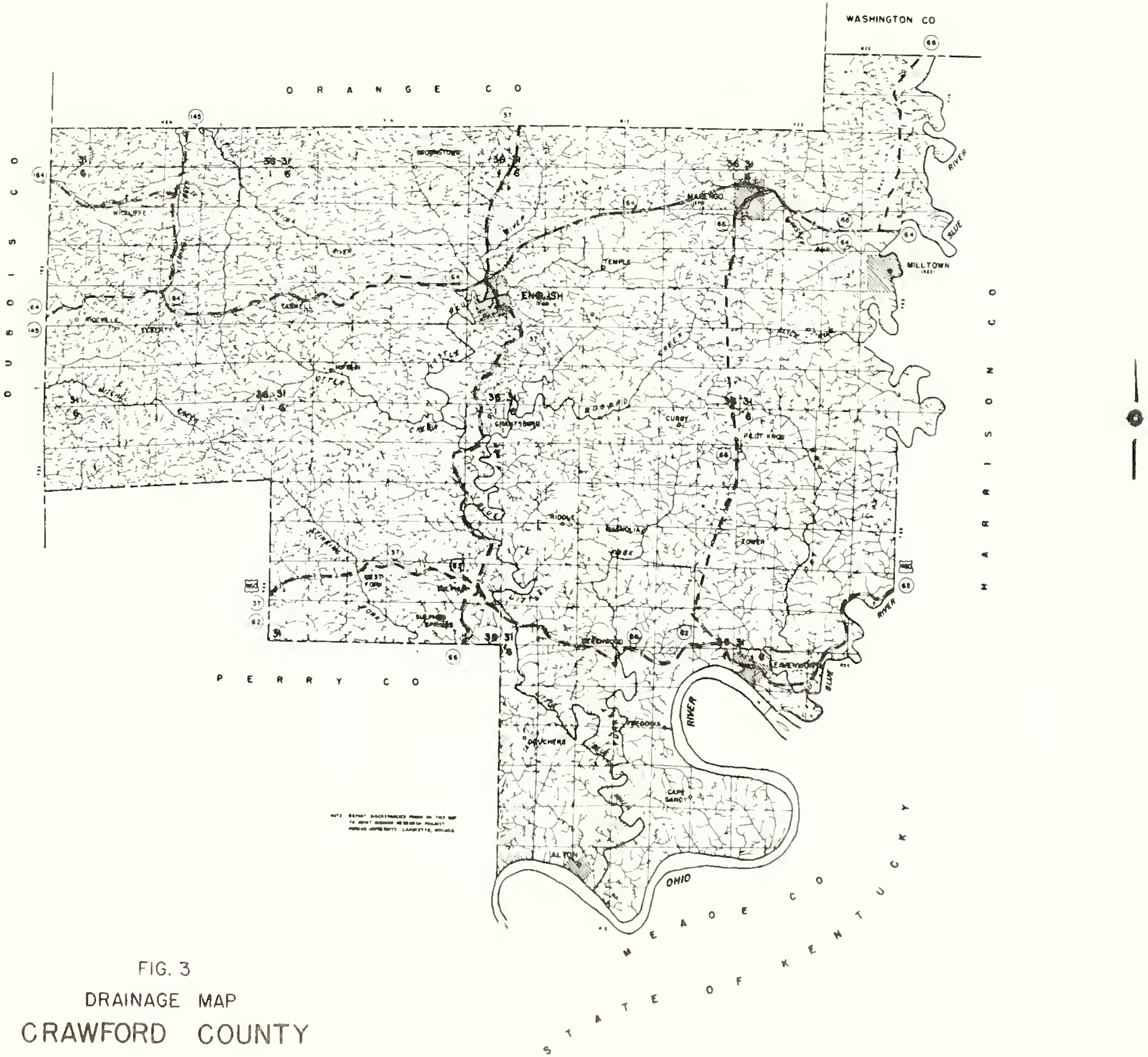


FIG. 3
DRAINAGE MAP
CRAWFORD COUNTY
INDIANA

There are no natural lakes in Crawford County. However, man-made ponds occur throughout the area. The biggest lake in Crawford County is the man-made English Reservoir along Brushy Creek.

Climate

The climate of Crawford County is continental, humid, and temperate. The warm humid summers and moderately cold winters are characterized by frequent sudden changes of temperature.

The climatalogical summary of temperature and precipitation of Crawford County prepared by L. A. Schaal, climatologist for Indiana, National Weather Service, U. S. Department of Commerce is listed in Table 1.

Physiography

Crawford County lies wholly in the Crawford upland region of the state (Figure 4). With respect to the physiographical situation in the United States, the county lies wholly in the Interior Low Plateaus province (6).

The Crawford upland is characterized by hills and ridges with deep valleys in between.

Topography

The topography of Crawford County is rather rugged in most parts of the county. This ruggedness is attributed to the erosion of the upland plains. The trench-like valleys with wall-like bluffs make the county one of the most inaccessible areas in the state. On the upland, high and low hills as well as narrow, flat ridges with various slopes and altitudes exist throughout the county. However, there is a broad and flat divide between the Blue River and the Little Blue River in the southeastern part of the county. Sinkholes and swallow holes are found along the Blue River region where limestone bedrock lies close to the surface.

Local relief of a magnitude of 250 ft (about 75 m) is quite common along the bluffs of the major rivers. Along the tributaries, a relief of 200 ft (or 60 m) is found. The maximum local relief of 397 ft (about 121 m) is in Sec. 27, T3S, R2E near Wyandotte cave. The highest elevation in Crawford County reaches an altitude of 950 ft (about 330 m) above sea level and it is located in Sec. 3, T2S, R1E. The lowest point of the county is about 383 ft (117 m) above sea level, where the Ohio River is bordered by Perry County to the west as shown in Figure 5.

Table 1: Temperature and Precipitation Data Crawford County.
Precipitation Data from Leavenworth, 1926-67, Temperature Data from Marengo, 1921-67

MONTH	TEMPERATURE				PRECIPITATION				
	AVERAGE DAILY MAXIMUM °F	AVERAGE DAILY MINIMUM °F	AVERAGE HIGHEST TEMPERATURE °F	AVERAGE LOWEST TEMPERATURE °F	AVERAGE TOTAL INCHES	ONE YEAR IN 10 WILL HAVE		DAYS WITH SNOW COVER OF 1 INCH OR MORE	AVERAGE DEPTH OF SNOW ON DAYS WITH SNOW COVER OF 1 INCH OR MORE
						LESS THAN INCHES	MORE THAN INCHES		
JANUARY	43	22	63	-3	4.1	1.3	8.0	5	3
FEBRUARY	45	23	67	1	3.3	0.9	6.7	4	3
MARCH	57	32	76	14	4.8	1.6	8.7	2	4
APRIL	67	40	85	25	4.0	1.4	6.5	0	0
MAY	77	50	90	35	4.4	1.1	8.2	0	0
JUNE	85	59	95	46	4.0	1.4	7.6	0	0
JULY	90	62	98	51	4.1	1.5	7.5	0	0
AUGUST	88	61	97	48	3.2	1.0	5.8	0	0
SEPTEMBER	82	54	94	37	2.9	1.0	5.7	0	0
OCTOBER	71	42	86	25	2.6	0.5	4.9	0	0
NOVEMBER	57	32	75	15	3.3	1.2	6.5	*	1
DECEMBER	45	24	64	3	3.1	1.2	5.4	2	2
YEAR	67	42	100	-11	43.8	30.3	57.0	13	3

* LESS THAN 0.5 DAY

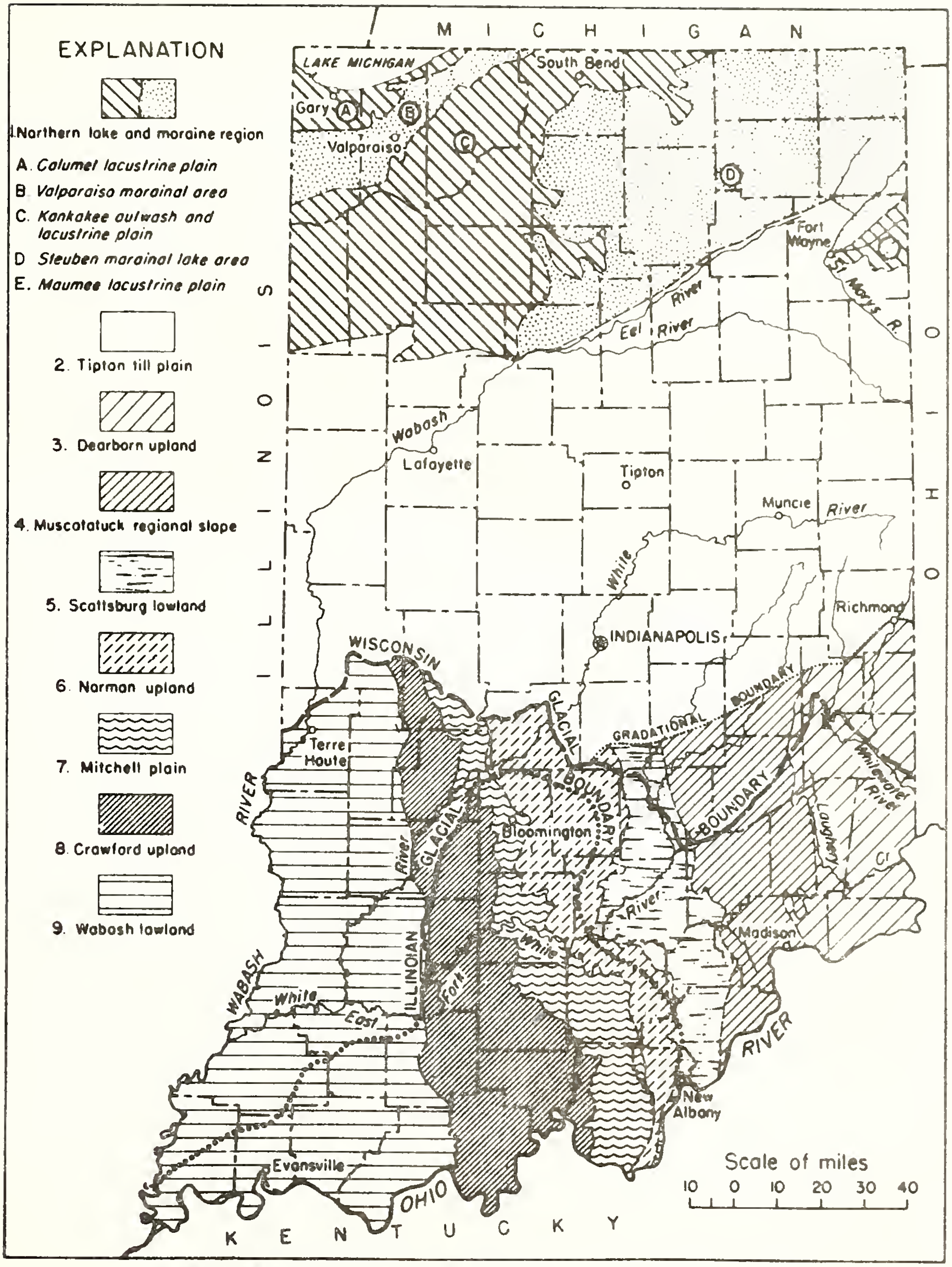


Figure 4 Map of Indiana showing regional physiographic units based on present topography. Modified from Malott

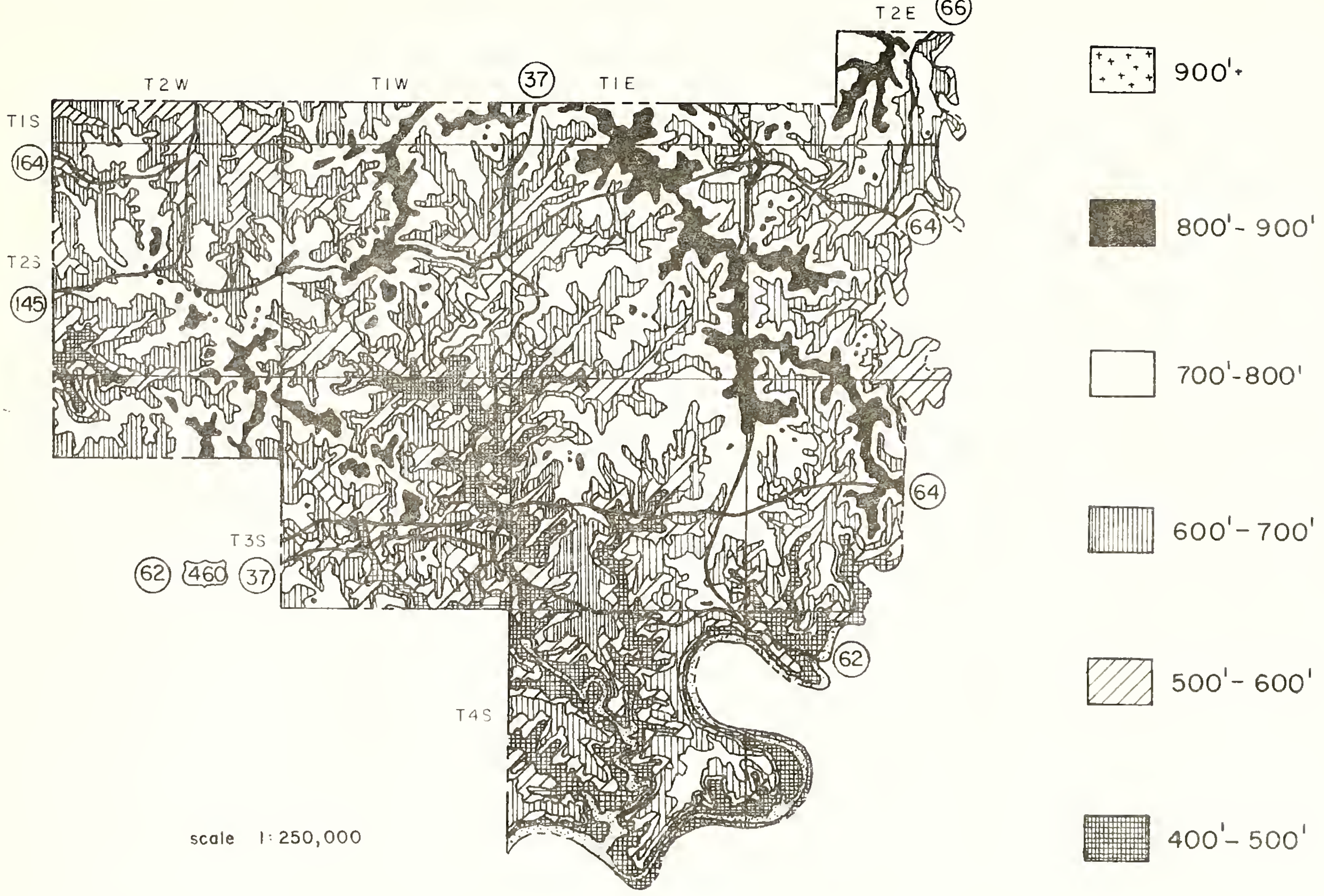


FIG. 5 TOPOGRAPHIC MAP OF CRAWFORD COUNTY

Scattered along the Ohio River and the lower reach of Blue River are a number of narrow terraces and lacustrine plains. The elevation of the terraces varies from 410 to 430 ft (125 to 131 m) above sea level. The lacustrine plain is slightly lower than the terrace with an altitude of 400 to 420 ft (122 to 128 m). Some low loess hills are found amidst the lacustrine plains.

A few stone quarries are located in Crawford County. Most of them are located in the limestone region.

Geology

The surface and near surface geologic ages represented in Crawford County are the Quaternary period with bedrock of Palezoic age. The Quaternary materials are both Pleistocene and recent in age.

The general surface deposits of Crawford County are shown in Figure 6. The area along the Ohio River, the Little Blue River, and Little Patoka River, and the Mitchel Creek are classified as clastic sediments of silt, sand, and gravel deposits of the Martinsville formation (7). Small areas along the Blue River, Little Blue River and Little Patoka River are classified as silt, sand and gravel deposits of the Prospect Formation. Along the lower reach of both Blue River and Little Blue River are the clay, silt and sand deposits of the lacustrine facies of the Atherton Formation (7). Two narrow stretches along the Ohio River are considered valley train deposits of gravel, sand and silt of the outwash facies of the Atherton Formation (7).

The upland area of the county is a residual soil area. The bedrock underneath the residual soil and the unconsolidated surface materials are rocks of the Pennsylvanian and Mississippian ages. The western third of the county consists of interbedded shale, sandstone, limestone, clay, and coal of the Raccoon Creek Group of the Pennsylvanian period (Figure 7) and this is underlain by the various colored shales, sandstones, and limestones of the late Chester Age of the Mississippian period.

The central portion of the county is underlain by limestone, sandstone, and shale of the Stephensport Group. When the sandstone of this series attain a thickness of 20 ft (6 m) or more, it usually gives rise to benches and bluffs and frequently caps hills and divides. Both the Hardinsburg sandstones and the Big Clifty sandstone of this group are outstanding bench and bluff formers. The Hardinsburg formation is composed of hard thin rippled marked sandstone layers frequently separated by thin bands of shale. As a unit it is remarkably resistant to erosion. This sandstone became a structural plain and formed a

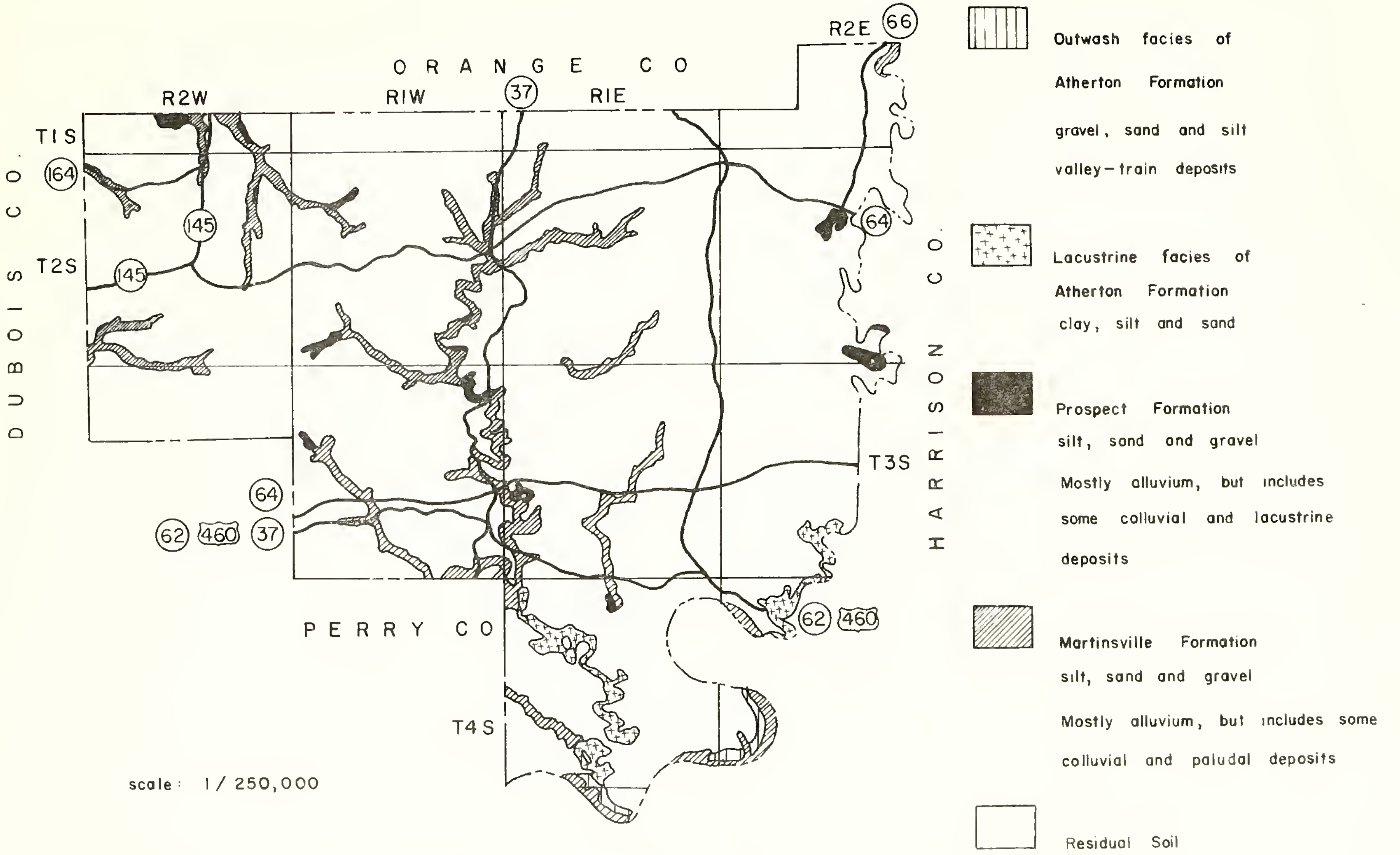

O R A N G E C O
D U B O I S C O.
H A R R I S O N C O.
P E R R Y C O
R2W
RIW
RIE
R2E
TIS
T2S
T3S
T4S
164
145
145
37
66
64
64
62
460
37
62
460
scale : 1 / 250,000
Outwash facies of Atherton Formation
gravel, sand and silt valley-train deposits
Lacustrine facies of Atherton Formation
clay, silt and sand
Prospect Formation
silt, sand and gravel
Mostly alluvium, but includes some colluvial and lacustrine deposits
Martinsville Formation
silt, sand and gravel
Mostly alluvium, but includes some colluvial and paludal deposits
Residual Soil

FIG. 6 UNCONSOLIDATED MATERIAL OF CRAWFORD COUNTY

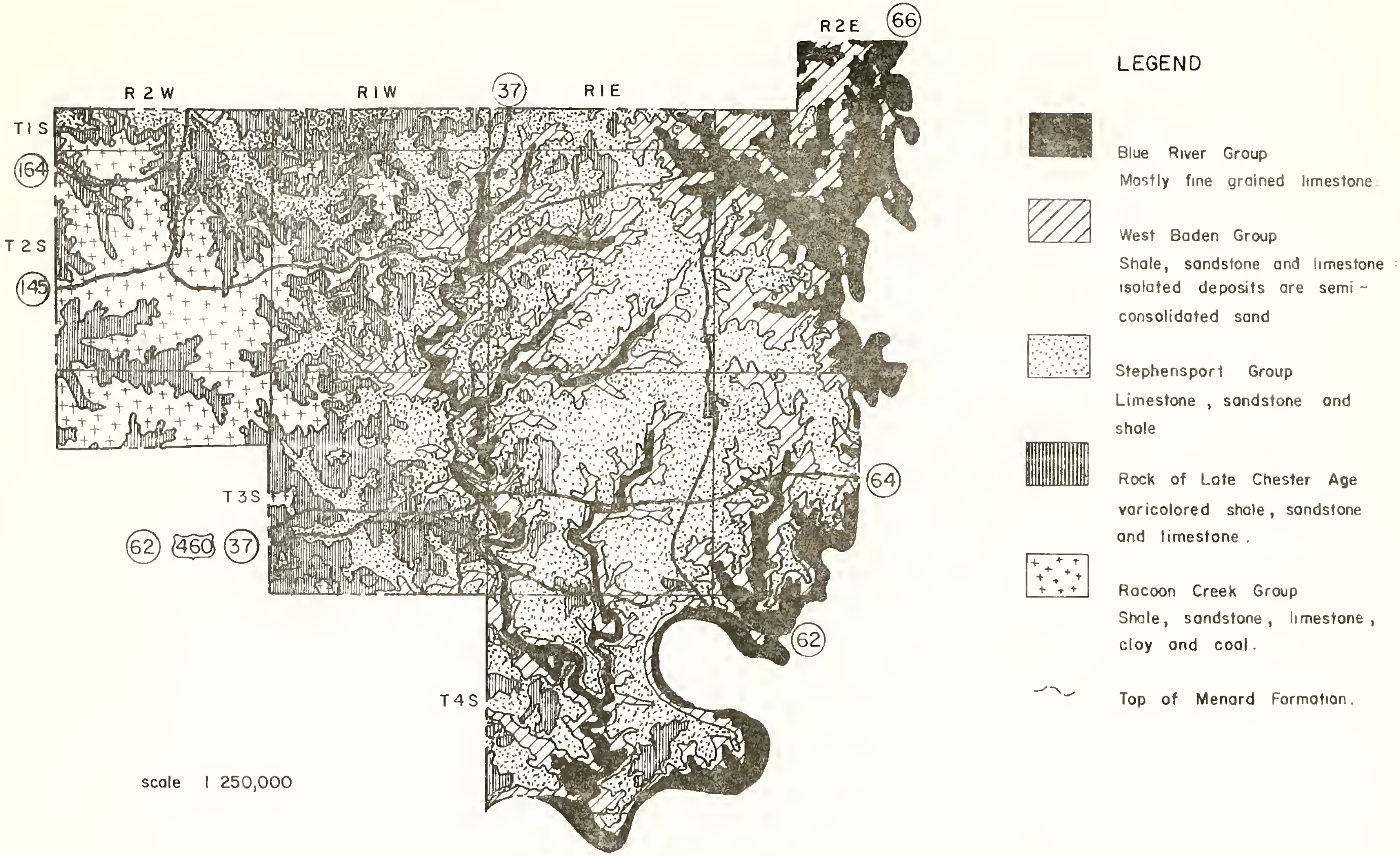

R 2 W
R I W
37
R I E
R 2 E
66
T I S
164
T 2 S
145
T 3 S
62
460
37
64
62
T 4 S
scale I 250,000
LEGEND
Blue River Group
Mostly fine grained limestone.
West Baden Group
Shale, sandstone and limestone : isolated deposits are semi-consolidated sand
Stephensport Group
Limestone , sandstone and shale
Rock of Late Chester Age
varicolored shale , sandstone and limestone .
Racoon Creek Group
Shale , sandstone , limestone , cloy and coal .
Top of Menard Formation.

FIG. 7 BEDROCK FORMATION OF CRAWFORD COUNTY

broad, flat divide between the Blue River and the Little Blue River in the eastern part of Crawford County. The Beach Creek limestone formation of this group, beneath the massive Big Clifty Sandstone formation (See Figure 8), is also a ledge former but is broken into blocks by two systems of joints.

The valley wall areas along both Blue River and the Little Blue River consist of shale, sandstone and limestone of the West Baden Group. The sample sandstone formation in this group is responsible for much of the topographic angularity along the Blue River.

The fine grained limestone of the Blue River group lies in the lower topographic region along the Blue River and the Little Blue River valleys. The Paoli formation is a compact Oolitic limestone. The St. Louis limestone formation is thin bedded with occasional beds of soft blue shale and shale partings. It is conspicuously jointed and cavernous. Caves and sinkholes occur in this formation. Chert also occurs commonly in stringers and layers.

A road cut exposure along SR 62 about one half mile (800 m) east of Sulphur in Sec 31. T3S, R1E. is shown in Figure 9. Eleven strata of the Chester formation totaling 296 ft (90 m) are exposed in the road cut as it descends West bluff of Little Blue River. The exposures begin with the thin Vienna Limestone at the top and end with the Beaver Bend on the river bank. The Tar Springs sandstone is poorly developed here (8).

Land Form and Engineering Soil Areas

The engineering soils in Crawford County are derived both from unconsolidated material and from the weathering of shale, sandstone and limestone bedrocks (See Figure 6). The residual soils occur in the uplands as well as along the valley walls. The unconsolidated materials include both fluvial deposits and eolian deposits. The fluvial deposits are confined to the valley and the low lands. The eolian deposits actually cover the entire surface of the county. The thicker eolian deposits, however, occur along the valleys and the bottom lands of the major rivers.

The deposits of transported materials are not homogeneous and variation should be expected. The profile and general properties of the soils for each area of different land forms are presented on the map that accompany this report.

Eolian Deposited Materials

There are extensive eolian (wind) deposits in Crawford County. Except for the alluvial plains, the entire county is covered by windblown silt or

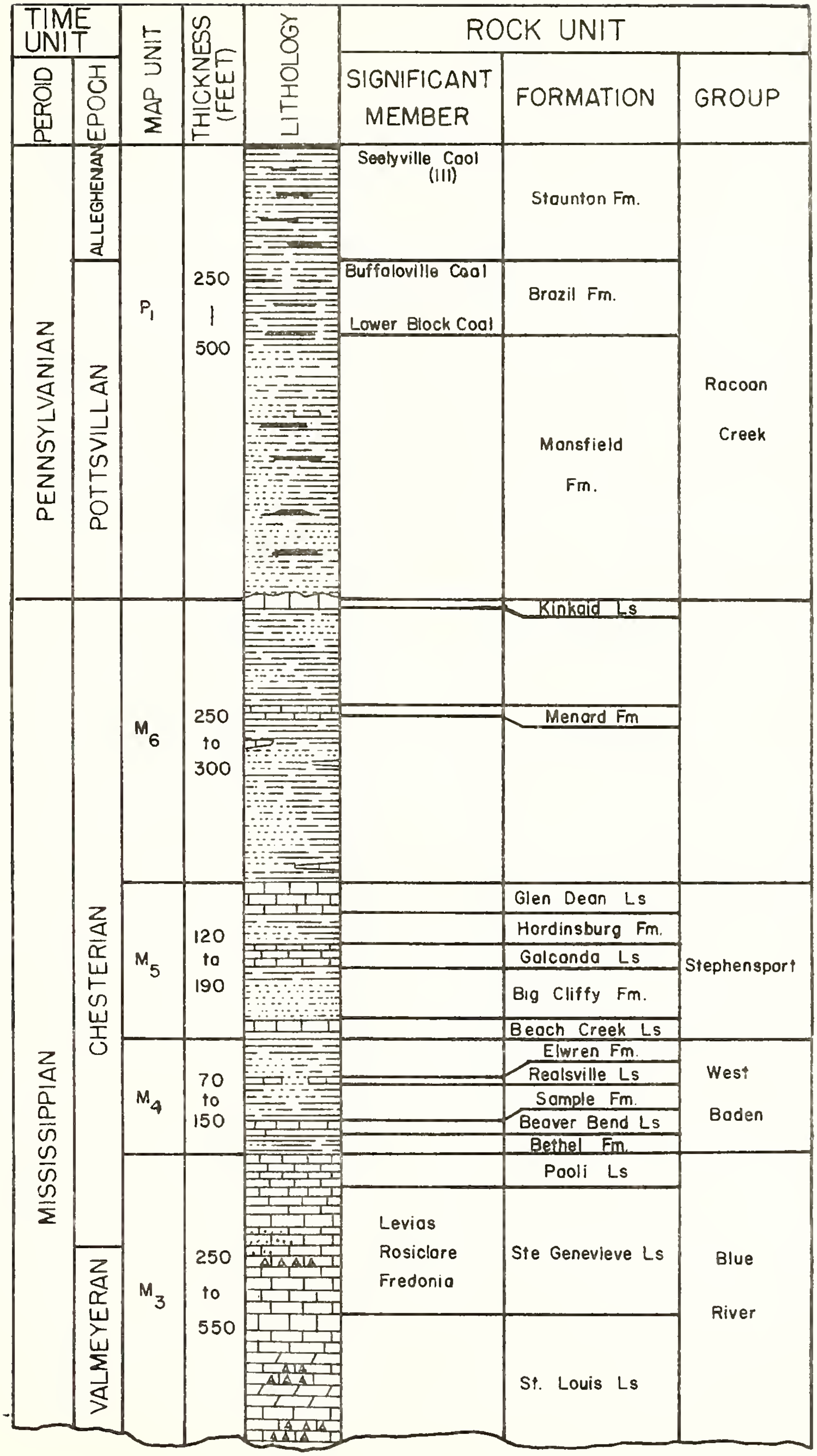
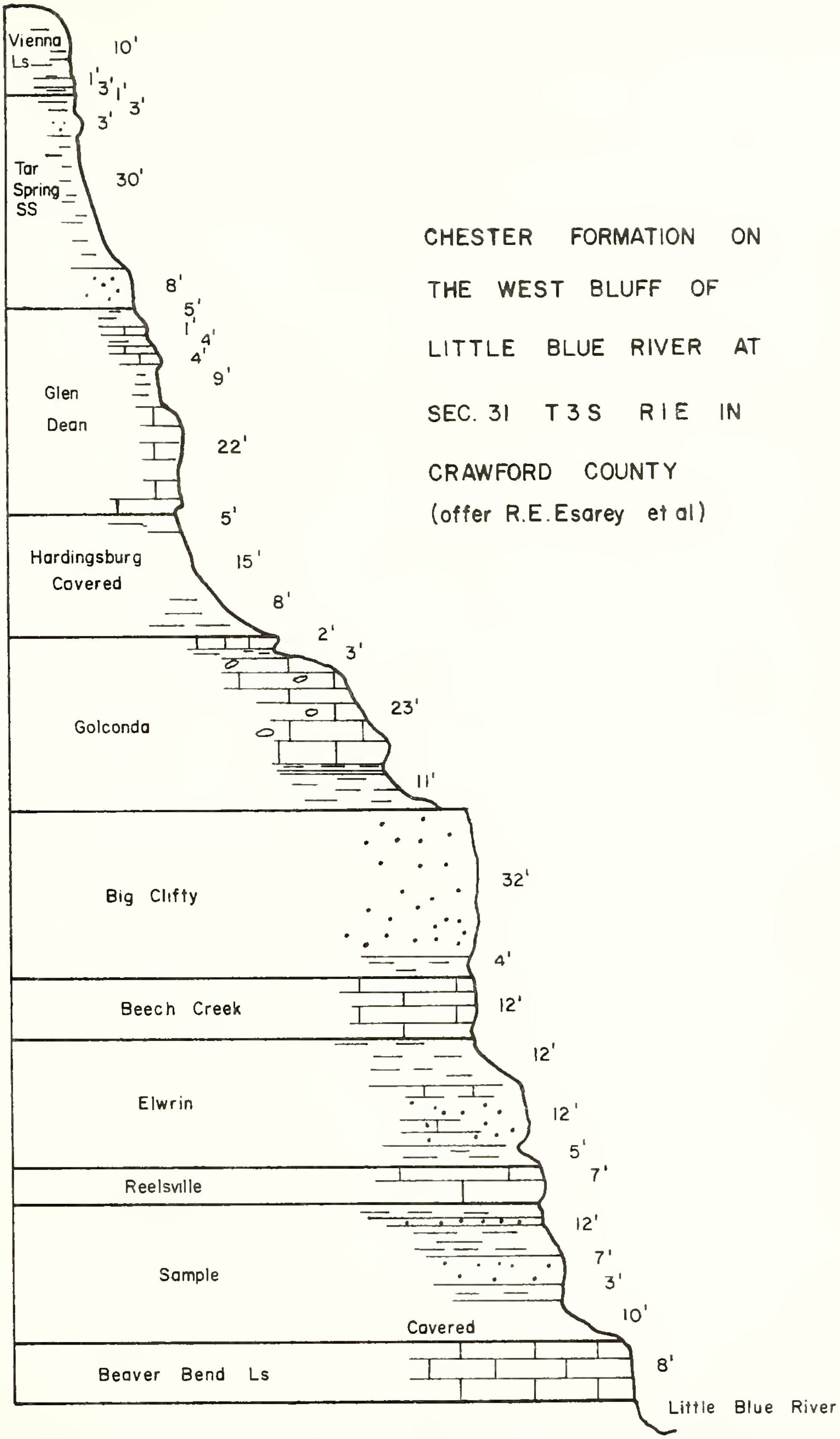


FIG. 8 COLUMNAR SECTION SHOWING BEDROCK UNITS IN CRAWFORD COUNTY



CHESTER FORMATION ON THE WEST BLUFF OF LITTLE BLUE RIVER AT SEC. 31 T3S R1E IN CRAWFORD COUNTY (offer R.E.Esarey et al)

FIG. 9 UPPER AND MIDDLE MISSISSIPPIAN FORMATION IN CRAWFORD COUNTY

loess deposits of varying depth. The loess deposits are subdivided into groups according to the depth of the loess and the type of underlying materials. The subdivisions are (a) moderately deep loess deposit, (b) loess covered lacustrine deposit (c) loess covered limestone, (d) loess covered sandstone-shale and (e) sandstone-shale with a loess veneer.

(a) Moderately Deep Loess Deposits

Only a few isolated small areas in Crawford County are classified as moderately deep (5 ft to 10 ft or 1.5 to 3 m) loess deposits. Most of the deposits are located within the lacustrine plains near the mouths of the Blue River and the Little Blue River.

The loess deposit exhibits an undulating topography and is only slightly higher than its surrounding lacustrine plains. The deposit is thickest at the center and decreases rapidly toward the edges. Because of its narrow width little or no surface drainage development is found on this deposit.

The soil profile of the moderately deep loess deposit generally has silt loam or silty clay loam (A-4 or A-6) soil in the A-horizon. The B-horizon soil is a more plastic silty clay loam to silty clay (A-6 to A-7-6). The C-horizon soil ranges from silt loam to silty clay loam (A-4 to A-6). However, in places the surface layer may contain considerable amounts of fine sand and is classified as loam or fine sandy loam. The C-horizon may have some thin strata of very fine sand. The mantle of loess is underlain by limestone, sandstone, and shale.

The engineering problems in this area involve primarily the control of moisture during construction and the compaction of the silty material. Erosion of the material and the influence of the bedrock should be considered.

(b) Loess Covered Lacustrine Deposits

About one half percent of Crawford County is classified as lacustrine deposits. This deposit, however, is covered by a thin loess blanket with a depth varying from 0 to 15 in (0 to 45 cm). This deposit is confined to the valley bottom of the lower reaches of the Blue River and the Little Blue River.

The lacustrine plain in Crawford County is about 420 ft (128 m) above sea level. The surface of this slack-water deposit was flat originally. However, with active erosion, the deposit within the county is only a remnant and the lacustrine plain is more accurately described as a lacustrine terrace. Erosion is severe along the edges of the terraces. Short gullys commonly develop along the border. The upper soil profile in the flat areas is essentially the same as that of the moderately deep loess deposits. However, at places where the slope is steep, the erosion is severe, and the loess blanket is entirely removed

and the soil profile is developed within the lacustrine deposits. The top soil varies from silt loam (A-4) in the high position to silty clay (A-6) in the low and severely eroded areas. The B-horizon is more clayey in texture ranging from a silty clay loam to silty clay (A-6, A-7). The C-horizon is derived from the slack water deposits consisting of stratified silt loam, silt clay loam, silt, and clay (A-6 to A-7).

Erosion and poor subgrade support are the major problems in this slack water lacustrine terrace deposit. The severe shrink-swell property of this deposit also needs to be considered.

(c) Loess Covered Limestone

About 7.5% of Crawford County is mapped as a loess covered limestone soil area. This soil region is concentrated in the northeastern corner of the county. Smaller isolated limestone soils are scattered in the eastern and southern parts of the county. A continuous strip is found near the confluence of the Blue River and the Ohio River at the southeastern corner of the county.

The limestone soil is developed on a rolling topography. Steep slopes are found along the drainage channels. A number of sinkholes appear in this region; however, they are few in number and are not distributed uniformly throughout the area. Some surface drainage development is observed on the airphotos. Many caves are formed in this region. The largest, Wyandotte Cave, is located at the southeastern corner of the county.

The soil developed in this region is derived from a loess mantle varying in thickness from less than 20 in to 40 in (from less than 50 cm to one meter). The thickest loess deposit is found on the nearly flat ridge tops and the thinnest deposit occurs along the steep slopes. The upper solum is derived from loess. The texture of the A-horizon varies from silt loam to silty clay (A-4 to A-6) soil. The B-horizon is more clayey and is classified as silty clay loam to clay (A-6 to A-7 soil). A dark red clay soil is usually found before the limestone bedrock is reached. This is the residual soil from the weathering of the limestone. Some chert fragments are found throughout the profile. The limestone bedrock is generally found at a depth of 60 to 120 in (1.5 to 3 m) in the gently sloping areas to less than a foot (30 cm) in the steeply sloped areas.

Boring Site No. 8 is on limestone bedrock. However, the 3.5 ft (more than one meter) layer of limestone bedrock is found 16.5 ft (5 m) below the ground surface. It is overlain by 5 ft (1.5 m) of shaly clay (A-6) and then 4 ft (1.2 m) of shaly clay loam (A-6) soil. The upper solum includes six

in (15 cm) of topsoil, 4.5 ft (1.37 m) of silty clay (A-6), and 2.5 ft (76 cm) of clay (A-7-6) soil (9).

Boring Site No. 31 is also located near the limestone area. However, no limestone was encountered 9 ft (2.75 m) below the surface (10).

The problems of this limestone region are invariably associated with cuts involving limestone rock excavation. In the sinkholes areas, the underground cavities and the capping of the sink hole need consideration. In the thick soil areas, however, the lack of adequate subgrade support and drainage are the problems.

(d) Loess Covered Sandstone - Shale

About one fifth of Crawford County is classified as loess covered sandstone-shale areas. The deposits occur along the ridge tops where the surface exhibits a 0-6% slope in general. Along the edges of the ridges, however, the slopes increase to 12%. The deposits are rather narrow throughout the county, however, a broad and flat continuous area is found between the Blue River and Little Blue River from Marengo to Leavenworth.

Since the sandstone-shale bedrock is covered by a blanket of loess with a thickness which varies from 18 to 48 in (45 cm to 1.2 m), the upper soil profile is derived from the loess material. The top soil is either a silt loam (A-4) or a silty clay loam (A-6) soil. The subsurface soil is a somewhat more clayey silty clay loam or silt clay (A-6 to A-7) soil. The weathered sandstone-shale residual soil is a sandy loam, silt loam, clay loam, or clay depending on the bedrock strata. Rock fragments are also mixed in this layer before sandstone or shale bedrock is reached.

The following boring sites are located inside this area. They are sites 2, 3, 4, 5, 8, 9, 13, 14, 20, 25, 26, 28, 29, 50, 51, 52, 53, 54, 65, 66, and 71. Beneath the silt loam top soil, silty clay loam (A-6) soil is most commonly found as illustrated in boring 3, 5, 20, 26, 28, and 65. However, soils with a slightly more clay content are found in other sites where the silty clay loam is classified as A-7-6 soil by the AASHTO system as illustrated in boring 13, and 14. Due to topographic position the clay (A-7-6) soil are found in the subsurface layer as seen at sites 9, 25, 66, and 71. The residual shale soil is generally classified as clay (A-7) soil with shaly fragments in the profile. Sandstone is generally found more than 15 ft (4.5 m) below the surface at these sites. The soil profile at site 26 with an altitude of 668 ft (204 m) above sea level shows that beneath a half foot (15 cm) of top soil there is 3.0 ft (90 cm) of silty clay loam (A-6) soil followed by 1.5 ft (45 cm) of very stiff clay (A-7-5), 3.0 ft (45 cm) of very dense sandy loam (A-4), 4.5 ft (1.4 m) of

sandstone, and 23.0 ft (7.0 m) of shale. The clay and sandy loam layers are the products of weathered shale and sandstone.

At site 54 sandstone is found much deeper beneath the surface. The site is at an elevation of 781 ft (240 m) above sea level. The profile shows that underlying the 0.5 ft (15 cm) of topsoil is 7.5 ft (2.3 m) of silty clay (A-7-6) soil and 8.5 ft (2.6 m) of shaly clay (A-7-6) soil followed by 18.0 ft (5.5 m) of sandstone, 1.0 ft (30 cm) of shale, and then alternately 4.0 ft (1.2 m) of sandstone, 2.5 ft (75 cm) of shale, and 10 ft (3 m) of limestone. The reader may get a better picture of the profile by referring to the soil profiles at sites 9, 10, 11, 12, 13, and 14.

The engineering soil problems in this soil region are generally associated with the different characteristics of the underlying residual bedrock soils and bedrock materials. A shallow cut and fill encounters several different materials in a short distance.

(e) Sandstone - Shale With Loess Veneer

About 65% of Crawford County is in the sandstone-shale with loess veneer category. They are located on both sides of the ridges and along the valley walls of the streams. The surface slope varies from 6% to 75%. Many gullies are developed in this region and the topography is extremely rugged and blocky.

The soil profile varies greatly depending on its topographic position, erosional situation, and rock types. Soils in the gently sloping areas are developed partly from thin loess and bedrock whereas in the steep slope areas or gully lands the loess and even the residual soil is removed and bedrock is exposed.

In a normal soil profile the top soil varies from a sandy loam to silty clay loam (A-4). It is underlain by silt loam or silty clay (A-4 to A-6) soil with considerable amount of stone fragments before the interbedded sandstone and shale bedrock is reached. The bedrock is generally found 20 to 60 in (50 cm to 1.5 m) from the surface. However, in the gully lands where erosion is severe, the top layer may be removed and the underlying bedrock exposed. This is considered as a non-soil area. In places, the sandstone and shale bedrock are well weathered and become clay, sandy loam and even sand in the profile before a solid bedrock is reached.

Many boring sites along interstate I-64 are in this area. Beneath the topsoil lie a silty clay loam or silty clay (A-4 to A-6) soil in general. However, it may be classified as A-7-6 soil as in boring site 12, 16, and 22. Sometimes, it may be classified as clay but is an A-6 soil by the AASHTO classification as illustrated at sites No. 68 and 73. Sandy loam (A-6 to A-2-4) soils are found in the profile below the B-horizon such as

at sites 6, 12, 38, 39, 46, and 69. At sites 55 and 63 there is 5 ft (1.5 m) of sand and 3.5 ft (1.05 m) of sandy loam underlying the topsoil. The layers are both classified as (A-2-4) soil by the AASHTO classification. Broken pieces of sandstone are found immediately below at site 55 and highly weathered sandstone with partly cemented sand or sandy loam occur at site 63. All these sandy loam, sand, and clay beneath the B-horizon are weathered shale and sandstone, The typical soil profile is illustrated at site 47. The top 1.5 ft (45 cm) of the profile is a silty clay loam (A-4) soil. It is immediately followed by 2.5 ft (75 cm) of silty clay (A-6) soil, 28.0 ft (8.5 m) thick strata of sandstone, and 10.5 ft (3.2 m) of shale.

Because of the proximity of shale bedrock at site 22, the profile shows 5.5 ft (1.65 m) of clay (A-7-6) soil underlying the 0.5 ft (15 cm) of topsoil. A 2 ft (60 cm) layer of shaly clay (A-7-6) followed immediately by 11.0 ft (3.3 m) of shale and 13.0 ft (3.35 m) of sandstone is encountered further down the profile.

At places where the limestone occurs there is the possibility of a solution cavity in the profile. Site 58 illustrates this fact. The profile consists of 1 ft (30 cm) of topsoil, 3.0 ft (45 cm) of silty clay loam (A-6), 8.5 ft (2.6 m) of shaly clay (A-7-6), then 0.5 ft (15 cm) of cavity, 4.5 ft (1.35 m) of weathered shale, 2.5 ft (75 cm) of limestone with shale and sandstone layers, another 2.0 ft (60 cm) of cavity and then 2.0 ft (60 cm) of limestone with sandstone fragments.

From the above examples the complexity of this region is recognized. The reader may get a better picture of the area by referring to the soil profiles at sites 9, 10, 11, 12, 13, and 14.

The engineering problems associated with this region are associated with variable cuts and fills. Different types and characteristics of residual soils and bedrock are encountered within a short distance both horizontally and vertically.

Fluvial Deposited Materials

About eight percent of Crawford County is covered by fluvial deposited materials. Three different land forms created by the action of water, namely lacustrine plain, terrace, and alluvial plain are discussed.

1. Lacustrine plain

Only a very limited area in Crawford County is classified as lacustrine deposit or slack water deposit. The lacustrine plains are formed in the lower valley of Blue River and Little Blue River. Since this deposit is

covered by a thin layer of loess, it was discussed previously under the heading of loess covered lacustrine plain.

2. Terrace deposits

A few scattered terrace deposits are recognized in Crawford County. Those along the Ohio River are quite different from the rest. Therefore, they are subdivided into high terrace and slack water terrace or low terrace.

(a) High terrace

Three separate high terraces are found along the Ohio River, current scars occur in all these terraces. However, infiltration basins which are a common feature of coarse-textured terrace deposits are absent. All the terrace surface and the lower one is subjected to flood erosion and deposition. Some surface drainage or erosion occurs in the high terrace and the surface is far from level. However, the lower terraces are more smooth and level in topography with little or no surface drainage on their surfaces. The altitude of the Ohio terrace varies from 410 to 420 ft (125 to 128 m) range.

The texture of the terrace varies greatly from place to place. In the high position, the surface soil ranges from a sandy loam to a silt loam (A-4). The B-horizon varies from sandy clay loam to silty clay loam (A-6). The parent material generally consists of stratified sandy loam, sand, silt loam, or silt with occasional gravel layers. In the low topographic position, the surface soil ranges from loam to silty clay loam (A-4 to A-6). The B-horizon is silty clay or clay (A-7). Stratified silt loam, silty clay loam, clay loam, or sandy loam is found in the parent material.

Settlement problems are expected in this area. For heavy structures, the subsurface soil should be investigated thoroughly.

(b) Slack Water Terrace

A number of small slack water terraces are recognized in Crawford County. They are scattered along Blue River, Little Blue River, and Little Patoka River.

The slack water terraces are extremely flat and only slightly higher than the adjacent flood plain. The topographic break between the flood plain and the slack water terrace is inconspicuous. Infiltration basins and current scars are completely missing on these terraces. Surface drainage is also absent.

In general, the soil of the slack water terrace is developed from stratified silt and fine sand. However, clay, clay loam, silt loam, and sandy loam is found in the profile.

The soil profile of this deposit consists of silt loam to silty clay loam (A-4) topsoil, silty clay loam to silty clay (A-4 to A-6), subsurface soil, and a somewhat less plastic subsoil (A-6). Stratified silt loam, silty clay loam, loam and fine sand is found at depth in the profile.

Boring site No. 19 is located in this region. Boring No. 19 is taken at the edge of the slack water terrace at an altitude of 441.5 ft (134.5 m) above sea level. A 9.0 ft (2.7 m) layer of loam (A-6) soil lies under a 0.5 ft (15 cm) layer of topsoil. A sandy loam (A-4) soil then follows to a depth of more than 12.5 ft (4.1 m) from the surface.

The major problems associated with this area are the high water table, instability of the silty soils, and occasional overflow and flooding.

3. Alluvial Plains or Flood Plains

More than two thirds of the fluvial deposits of Crawford County belong to the alluvial plains or flood plains. The extent of mapping of these plains was determined by the engineering soils map scale. Due to the different sources of the alluvial materials and the different forms of their deposition, the flood plains in this county are subdivided into Ohio River flood plains and alluvial plains in the sandstone - shale region.

(a) The Ohio River Flood Plains

The Ohio River flood plains are rather narrow in Crawford County. The plain has a near flat surface. Current scars, infiltration basins and surface drainage are absent from these narrow plains. A definite topographic break is observed between these flood plains and their adjacent terraces or uplands.

The soil profile generally consists of silt loam or silty clay laom (A-4) topsoil. However, sandy loam soil is found occasionally. The subsurface soils are a silt loam or silty clay loam (A-4 to A-6) texture. The subsoils are generally of the same texture but lighter in color. Stratified silt loam and silty clay loam are found further down the profile. Mica flakes are found in the soil and seams of sand are often encountered throughout the profile.

The major engineering problem is associated with flood or high water, the danger of scour, and the weak supporting power of the unconsolidated deposits.

(b) Alluvial Plain in the Sandstone Shale and Limestone Region

The major part of the alluvial plains in Crawford County belong to this category. The alluvial plains are narrow and deeply entrenched. The alluvial

plain slopes gently from the upper reach toward the lower reach with a steeper gradient at the upper end.

The deposits of the alluvial plains are derived from the erosion of the surrounding loess covered sandstone and shale uplands and to a lesser extent from the loess covered limestone uplands. The highly erosive loess fills the valleys with silty deposits. A coarser textured material is found adjacent to the foot of the upland and a finer textured deposit further down stream.

The soil profile varies from a silt loam to a silty clay loam (A-4 to A-6) topsoil with a similar subsurface soil which is underlain by stratified silt loam, loam and sand loam with sandstone fragments further down the profile.

A few boring sites along I-64 are located in this area. Boring site 32 is located in the flood plain of Turkey Fork. The profile shows that beneath 0.5 ft (15 cm) of topsoil is a 2.0 ft (60 cm) layer of loam (A-6) soil followed by 3.5 ft (1.05 cm) of partially cemented sandy loam (A-2-4) soil.

At sites 35 and 36 a silty clay loam (A-4) soil of 2 to 3 ft (60 to 90 cm) lies under the 0.5 ft (15 cm) of topsoil. A 5 ft (1.5 m) layer of sand (A-1-b) follows immediately below the 3 ft (90 cm) strata of silty clay loam at site 35. However, a 7 ft (2.1 m) layer of sandy loam (A-2-4) is found underlying the 2 ft silty clay loam subsurface soil at site 36.

The boring along SR 37 located at site 74 is quite different from the other sites. The site is located in the flood plain and near the foot of the bank of the Little Blue River. The profile consists of 5 ft (1.5 m) of very soft silty clay loam (A-4), followed by 5 ft (1.5 cm) of clay (A-6), and then by more than 4.5 ft (1.35 m) of very loose sandy loam (A-2-4) soil (14).

The engineering problems in this area are associated with high water and frequent flooding. Subgrade support is poor during the wet seasons. Settlement is a problem for heavy structures.

Miscellaneous

Quarries

There are a number of quarries in Crawford County, most of them are limestone quarries. However, the one located southeast of Taswell is a sandstone quarry reported by the soil survey of Crawford County (1).

Strip Mines

A small strip mine is located southwest of Grantsburg also reported by the soil survey of Crawford County (1).

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APPENDIX A

The soil test data tabulated below was obtained from consultants' reports prepared for the Indiana State Highway Commission. The location of the site is shown on the attached engineering soils map. Considerable additional data is contained in the consultants' reports.

Site	Station	Offset (ft.)	Depth (ft.)	Texture	AASHTO Classification	Percent Gravel	Percent Sand	Percent Silt	Percent Clay	L.L.	P.L.	P.I.	S.L.
1	2251+50	100R	8.5-9.2	Clay (or soft shales)	A-7-6(12)	0	3	49	48	42	22	20	20
2	2261+25	42R	0.5-3.0	Sa.L.	A-4(0)	25	39	17	9	20	17	3	18
3	2271+00	70L	4.0-6.0	Cl(shaly)	A-7-6(20)	4	10	41	45	86	27	59	14
4	2318+05	70R"A"	12.5-14.0	Cl(shaly)	A-7-5(17)	0	0	26	74	57	33	24	17
5	2321+95	42R	1.0-4.0	Si.Cl.L.	A-6(8)	6	19	52	23	32	21	11	22
6	2339+60	70R	1.5-2.0	Si.Cl.	A-6(10)	0	8	62	30	34	20	14	19
7	3344+70	42R	3.5-4.5	Sa.L.	A-6(6)	17	43	29	11	37	20	17	18
			11.5-12.5	Sa.Cl.L.	A-6(2)	11	55	13	21	31	16	15	16
			13.5-14.5	Cl.L.(sh)	A-6(10)	15	28	33	24	35	16	19	15
8	2363+00	42R	13.0-14.5	Cl(shaly)	A-6(10)	2	16	41	41	40	24	16	19
9	2368+05	42R	0.5-4.0	Clay	A-7-6(19)	0	10	43	47	54	24	30	15
			6.5-7.0	Sa.L.	A-4(1)	25	47	20	8	21	19	2	20
10	2405+25	70L"AL"	16.0-17.5	Cl (or soft shale)	A-7-6(12)	4	33	25	38	48	27	21	22
11	2412+50	70R	2.0-5.0	Clay	A-7-6(19)	4	9	35	52	55	25	30	16
			5.0-8.0	Cl(shaly)	A-7-6(20)	0	1	29	70	62	28	34	15
12	2447+50	70R	6.0-7.5	Sa.L.	A-6(5)	48	29	15	8	40	19	21	16
13	2456+00	70R	0.5-2.0	Si.Cl.L.	A-7-6(10)	0	2	74	24	41	27	14	25
14	470+50	70R	7.0-9.0	Clay	A-7-5(20)	2	5	66	27	83	34	49	21
			9.0-10.0	Cl(shaly)	A-7-6(18)	9	18	29	44	52	19	33	12

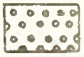
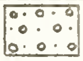
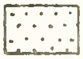
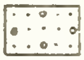
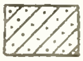
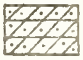
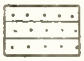
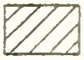
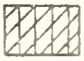
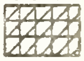
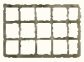
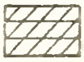
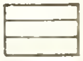
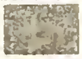
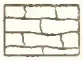
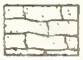
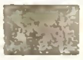
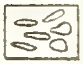
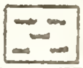
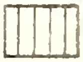
Site	Station	Offset (ft.)	Depth (ft.)	Texture	AASHTO Classification	Percent				L.L.	P.L.	P.I.	S.L.
						Gravel	Sand	Silt	Clay				
15	477+50	70L	0.5-2.0	Si.Cl.L.	A-7-6(13)	0	5	67	28	45	26	19	24
			2.0-4.0	Loam	A-4(4)	12	39	38	11	27	17	10	22
16	508+00	76L	3.5-5.0	Si.Cl.L.	A-4(8)	0	26	51	23	30	23	7	18
17	539+50	70R	1.0-2.5	Sa.L.	A-1-b(0)	54	35	6	5	25	23	2	26
			9.0-10.5	Si.Cl. (shaly)	A-7-6(14)	0	1	65	34	46	24	22	18
18	557+00	42L	14.0-15.5	Si.L.	A-6(8)	1	11	70	18	31	20	11	27
19	566+00	70L	2.0-4.0	Loam	A-6(6)	1	39	41	19	27	16	11	19
			10.5-12.5	Sa.L.	A-4(1)	0	65	22	13	20	NP	NP	19
20	574+00	100R	0.5-2.0	Si.Cl.L.	A-6(10)	0	5	72	23	35	21	14	24
			2.0-4.0	Si.L.	A-6(10)	1	12	70	17	36	20	16	22
21	581+00	125L	16.0-17.5	Sa.Cl.L.	A-6(7)	19	44	15	22	37	14	23	14
22	588+50	70L	1.0-2.0	Clay	A-7-6(20)	1	11	34	54	65	26	39	13
23	392+00	42R	12.0-14.0	Clay	A-7-6(20)	3	18	24	55	66	21	45	11
24	608+00	10R	0.0-2.0	Cl(shaly)	A-7-6(19)	9	15	31	45	54	23	34	13
25	622+80	70L	4.0-6.0	Clay	A-7-6(20)	0	18	24	58	79	28	51	28
26	9+00	70L	0.5-2.0	Si.Cl.L.	A-6(10)	0	10	64	26	39	25	14	22
			5.5-6.5	Sa.L.	A-4(2)	32	42	14	12	24	18	6	17
27	11+50	CL	10.0-12.0	Cl(shaly)	A-7-6(20)	5	10	22	63	67	25	42	14
28	30+00	42L	2.0-12.0	Clay	A-7-6(19)	3	19	19	59	54	19	35	16
29	39+00	42R	9.0-13.5	Clay	A-7-5(20)	4	6	17	73	47	31	66	14
30	68+50	70R	1.0-2.0	Sa.L.	A-2-4(0)	53	33	10	4	27	19	8	21
31	78+75	CL	2.0-4.0	Clay	A-7-6(19)	3	12	45	40	56	24	32	14
			6.0-7.0	Cl(shaly)	A-7-5(20)	1	7	38	54	68	30	38	18
32	102+00	130R	2.5-4.0	Sa.L.	A-2-4(0)	43	40	13	4	23	17	6	23

Site	Station	Offset (ft.)	Depth (ft.)	Texture	AASHTO Classification	Gravel	Sand	Silt	Clay	L.L.	P.L.	P.I.	S.L.
33	108+00	100R	1.0-2.0	Loam	A-6(5)	36	29	26	9	31	18	13	20
34	118+00	70L"AL"	6.0-7.5	Sand	A-2-4(0)	1	90	7	3	NP	NP	NP	NP
35	135+00	42R"AL"	3.5-5.0	Sand	A-1-b(0)	63	31	4	1	NP	NP	NP	NP
36	136+00	CL	3.5-5.0	Sa.L.	A-2-4(0)	47	40	10	3	NP	NP	NP	NP
37	148+00	100R	9.0-10.0	Clay	A-7-6(20)	2	11	25	62	73	26	47	12
			14.5-16.0	Clay	A-6(8)	0	46	22	32	39	18	21	18
38	162+00	CL"AL"	0.5-2.0	Si.Cl.L.	A-4(8)	0	6	70	24	29	22	7	23
			2.5-4.0	Cl.L.	A-6(8)	7	36	30	27	34	18	16	19
39	162+00	94R	14.5-16.0	Cl.L.	A-4(8)	1	34	44	21	25	16	9	18
40	171+00	70R"AL"	0.5-2.0	Si.Cl.	A-6(10)	1	7	54	38	37	21	16	21
41	174+00	42L"AL"	2.5-4.0	Sa.L.	A-2-4(0)	47	37	10	6	26	17	9	18
42	178+00	150R	4.0-5.0	Cl(shaly)	A-7-6(16)	4	12	30	54	47	20	27	13
43	179+00	70L"AL"	3.0-5.0	Clay	A-7-6(20)	0	7	22	71	58	23	35	12
44	182+00	70R	12.0-14.0	Clay	A-6(9)	8	28	32	32	30	15	15	15
45	189+00	70R	2.0-4.0	Cl.L.	A-4(7)	13	31	37	19	24	16	8	17
46	197+00	10R"AL"	5.0-5.9	Sand	A-2-6(0)	62	30	4	4	28	17	11	18
47	205+00	100L"AL"	0.0-1.5	Si.Cl.L.	A-4(8)	0	9	65	26	29	21	8	22
48	207+00	CL	0.5-1.5	Clay	A-7-6(20)	5	12	36	47	61	29	32	17
49	215+00	CL"AL"	10.0-12.5	Clay	A-7-6(17)	1	8	30	61	49	21	28	14
50	225+00	10L"BL"	5.0-7.0	Clay	A-6(12)	13	21	34	32	38	17	21	12
51	225+00	70R"B"	6.0-8.0	Cl(shaly)	A-7-6(16)	13	18	28	41	46	18	28	13
52	237+50	100R"B"	3.0-4.0	Clay	A-7-6(20)	1	4	41	55	74	24	50	20
			21.0-23.0	Clay	A-7-6(20)	1	5	44	51	63	24	39	17
53	241+25	45L"BL"	1.0-2.0	Si.L.	A-4(8)	1	8	74	17	29	21	8	22
			2.0-4.0	Sa.L.	A-2-4(0)	41	40	13	6	26	18	8	18
			10.5-10.9	Cl. or shale	A-6(11)	3	14	38	45	37	19	18	15

Site	Station	Offset (ft.)	Depth (ft.)	Texture	AASHTO Classification	Percent				L.L.	P.L.	P.I.	S.L.
						Gravel	Sand	Silt	Clay				
54	279+00	70L"BL"	11.0-13.0	Cl(shaly)	A-7-6(15)	7	20	43	30	45	20	25	14
55	290+50	70R"B"	0.5-2.0	Sand	A-2-4(0)	27	62	7	4	NP	NP	NP	NP
56	325+00	42L"BL"	5.0-6.5	Clay	A-7-6(20)	2	22	24	52	68	22	46	15
57	339+50	70R"B"	17.5-19.0	Sa.L.	A-2-4(0)	20	62	16	2	NP	NP	NP	NP
58	347+50	70L"B"	5.0-7.0	Cl(shaly)	A-7-6(17)	8	23	37	32	48	20	28	18
59	349+75	45L"B"	3.0-5.0	Cl(shaly)	A-7-6(17)	0	4	48	48	51	23	28	14
60	350+00	CL"B"	0.5-2.0	Si.Cl.L.	A-6(9)	0	12	60	28	35	22	13	20
61	353+50	70L"B"	0.5-2.0	Si.Cl.	A-7-6(16)	1	8	58	33	46	20	26	21
62	363+00	70L"B"	7.0-8.0	Clay	A-7-6(20)	4	8	40	48	91	26	65	15
63	388+00	42L"B"	0.5-2.0	Sa.L.	A-2-4(0)	30	48	16	6	NP	NP	NP	NP
64	398+00	42L	0.5-2.0	Cl. Loam	A-6(8)	1	29	45	25	29	17	12	17
65	402+80	42L	0.5-2.0	Si.Cl.L.	A-6(11)	0	8	68	24	40	23	17	25
66	407+00	70R	3.0-5.0	Clay	A-7-6(20)	2	7	27	64	95	27	68	24
67	420+00	70R	9.5-11.0	Cl(shaly)	A-7-6(18)	5	9	34	52	55	28	27	15
68	459+00	70R	0.5-2.0	Clay	A-6(8)	4	34	32	30	33	19	14	16
69	468+00	70R	6.0-8.0	Clay	A-7-6(20)	0	8	38	54	61	24	37	14
			9.0-11.0	Sa.L.	A-2-4(0)	15	61	15	9	NP	NP	NP	NP
			11.0-12.5	Cl(shaly)	A-7-6(17)	4	7	42	47	47	19	28	15
70	477+50	42R	0.5-1.5	Si.Cl.L.	A-6(9)	0	4	68	28	36	24	12	24
71	710+00	38R	1.0-4.0	Clay	A-7-6(44)	6	3	21	70	65	21	44	
			4.0-14.0	Wthr.Sh. w/SS	A-7-6(20)	20	11	23	46	47	15	32	
72	725+00	38R	1.5-4.0	Sa.Cl.L.	A-6(2)	7	51	15	26	28	14	13	
73	725+00	38L	2.5-8.5	Clay	A-6(22)	1	13	45	41	40	14	26	
74	760+00	55L	13.5-15.0	Sa.L.	A-2-4(0)	0	69	22	9	NP	NP	NP	
75	763+00	38L	18.5-28.0	Clay	A-7-6(31)	1	5	24	70	49	17	32	

APPENDIX B

SOIL CLASSIFICATION AND PROFILE SYMBOLS

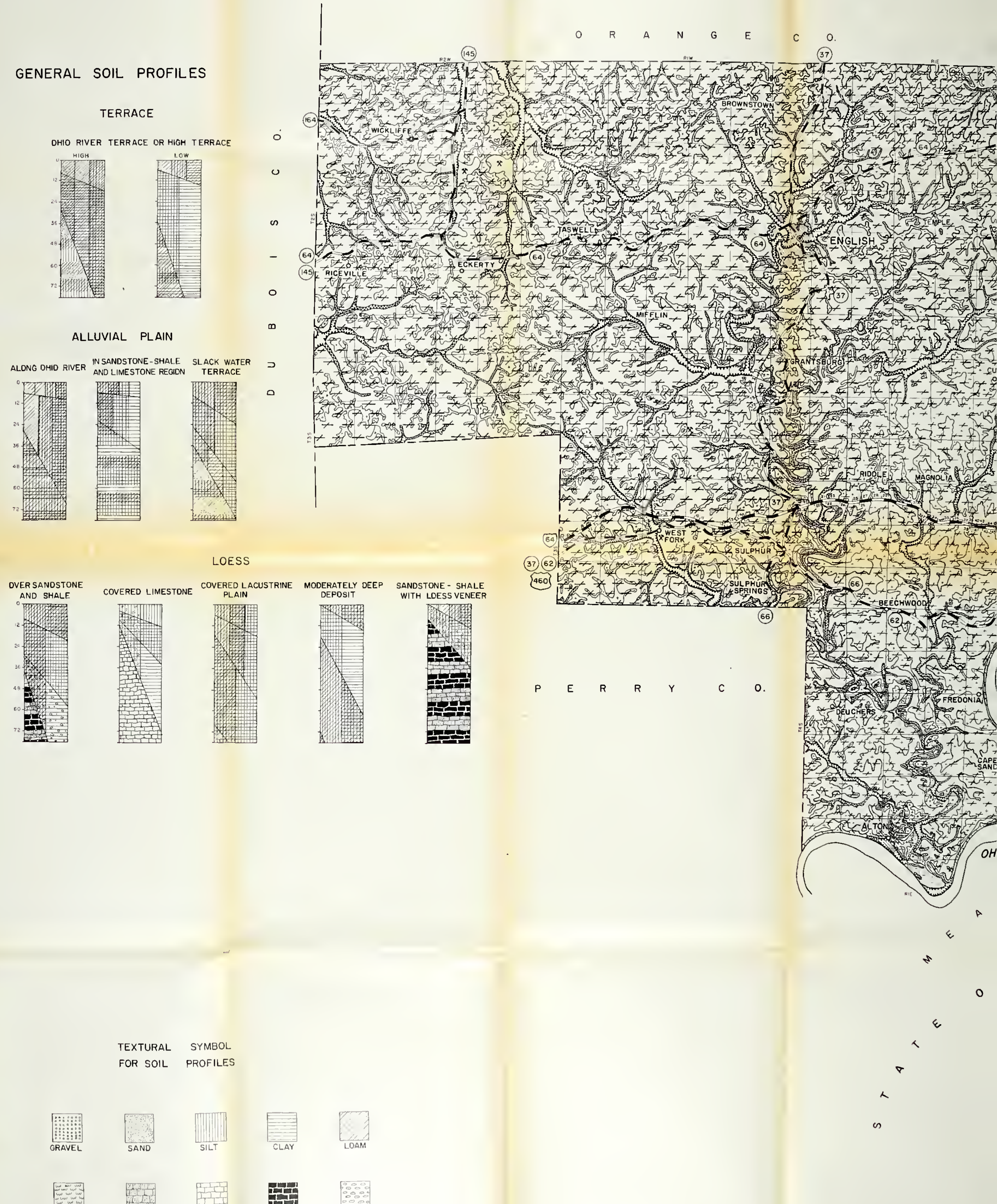
Description	Grain Size Distribution				Plastic Index	Symbol
	Gravel % Retained on #10	Sand #10–#200	Silt 0.05–0.005mm	Clay Less than 0.005mm		
Gravel	85–100	0–15	0–10	0–10	NP	
Sandy Gravel	50–85	15–50	0–10	0–10	6 Max.	
Sand	0–15	85–100	0–10	0–10	NP	
Gravelly Sand	20–49	45–85	0–10	0–10	6 Max.	
Sandy Loam	0–19	50–80	0–50	0–20	6 Max.	
Sandy Clay Loam	0–19	50–80	0–30	20–30	10 Max.	
Sandy Clay	0–19	55–70	0–15	30–45	11 Min.	
Loam	0–19	30–50	30–50	0–20	10 Max.	
Silt Loam	0–19	0–50	50–100	0–20	10 Max.	
Silty Clay Loam	0–19	0–30	70–100	20–30	11 Min.	
Silty Clay	0–19	0–15	55–70	30–45	11 Min.	
Clay Loam	0–19	20–50	50–80	20–30	11 Min.	
Clay	0–19	0–55	0–55	30–100	11 Min.	
Peat or Muck						
Limestone						
Sandstone						
Shale						
Stony Fragments						
Organic Matter						
Topsoil						

Classification of Gravelly Soils

85%–100%	gravel plus finer material	Gravel
50%–84%	gravel plus finer material	Clayey, silty or sandy gravel
20%–49%	gravel plus finer material	Use fine classification and called gravelly sand, gravelly silt or gravelly clay
0%–19%	gravel plus finer material	Use fine classification only

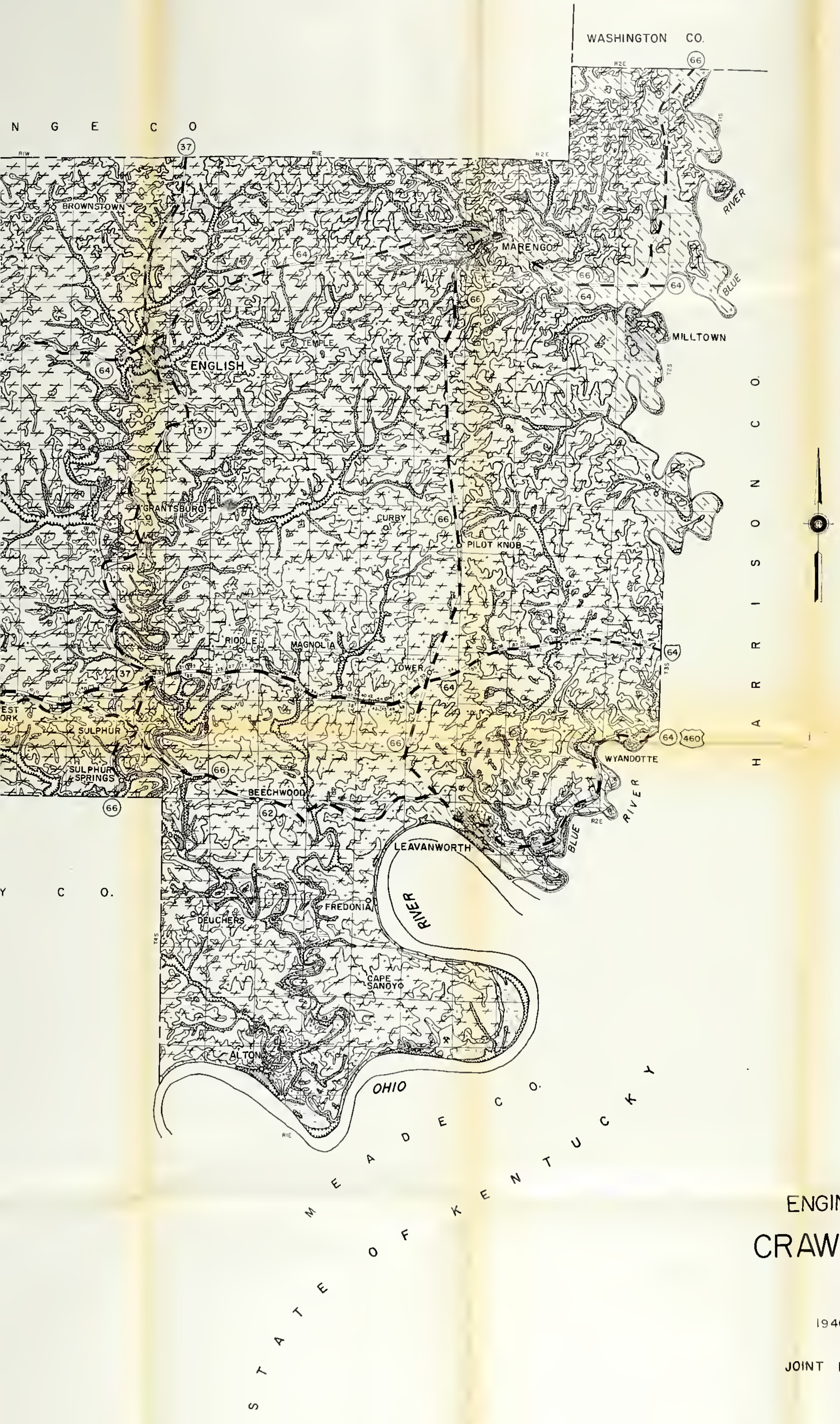
IN [illegible]

IN/JHRP-81/1



PREPARED UNDER THE SUPERVISION OF P T YEH

DRAWN BY P TOURNEY AND S ARIAEY-NEJAD



LEGEND

PARENT MATERIAL
(GROUPED ACCORDING TO LAND FORM AND ORIGIN)

- MODERATELY DEEP LOESS PLAIN
- LOESS COVERED LACUSTRINE PLAIN
- LOESS COVERED SANDSTONE - SHALE
- INTERBEDDED SANDSTONE - SHALE WITH LOESS VENEER
- LOESS COVERED LIMESTONE
- TERRACE
- SLACK WATER TERRACE
- ALLUVIAL PLAIN

MISCELLANEOUS

- BORING SITE
- LAKE OR POND
- LIMESTONE QUARRY

TEXTURAL SYMBOLS
(SUPERIMPOSED ON PARENT MATERIAL TO SHOW RELATIVE COMPOSITION)

- GRAVEL
- SAND
- SILT
- CLAY

ENGINEERING SOILS MAP
CRAWFORD COUNTY
INDIANA

PREPARED FROM
1940 AAA AERIAL PHOTOGRAPHS
BY
JOINT HIGHWAY RESEARCH PROJECT
AT
PURDUE UNIVERSITY
1981

SCALE OF MILES
3/4 1/2 1/4 0 1 2 3 4

DRAWN BY P TOURNEY AND S ARIAEY-NEJAD

COVER DESIGN BY ALDO GIORGINI